



US009470797B2

(12) **United States Patent**  
**Walgren et al.**

(10) **Patent No.:** **US 9,470,797 B2**  
(45) **Date of Patent:** **Oct. 18, 2016**

(54) **SYSTEM AND METHOD FOR ASSET TRACKING CONFIGURATION OF A MOBILE TERMINAL**

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(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 155 days.

(21) Appl. No.: **14/478,481**

(22) Filed: **Sep. 5, 2014**

(65) **Prior Publication Data**

US 2014/0375498 A1 Dec. 25, 2014

**Related U.S. Application Data**

(62) Division of application No. 13/235,641, filed on Sep. 19, 2011, now Pat. No. 8,830,124.

(60) Provisional application No. 61/384,135, filed on Sep. 17, 2010.

(51) **Int. Cl.**

<b>G01S 19/24</b>	(2010.01)
<b>G01S 19/34</b>	(2010.01)
<b>G01S 3/02</b>	(2006.01)
<b>G01S 19/13</b>	(2010.01)
<b>G01S 19/09</b>	(2010.01)
<b>G01S 19/14</b>	(2010.01)
<b>G01S 5/00</b>	(2006.01)

(52) **U.S. Cl.**

CPC ..... **G01S 19/13** (2013.01); **G01S 5/0027** (2013.01); **G01S 19/09** (2013.01); **G01S 19/14** (2013.01); **G01S 19/24** (2013.01); **G01S 19/34** (2013.01)

(58) **Field of Classification Search**

USPC ..... 342/357.26, 357.34, 357.51, 357.63, 342/357.74, 457; 701/468, 469; 340/539.13, 539.14

See application file for complete search history.

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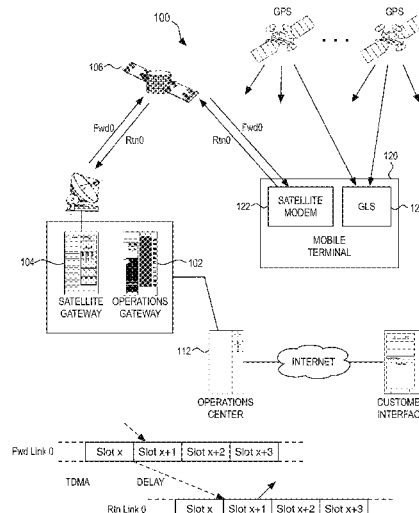
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(57)

**ABSTRACT**

Various implementations of the invention comprise a position tracking module, a transmitter, and a controller. The position tracking module collects measurements from a plurality of positioning satellites, where the collected measurements may be used to determine a position of said mobile terminal. The transmitter transmits status reports to an operations center. The controller controls an activation of the transmitter based on an analysis of a geographic cost function, where the geographic cost function identifies a geographic area in which the controller alters a communication parameter of the mobile terminal. The alteration of the communication parameter may be used by the operations center as a basis for a change in a billing rate during at least part of a time that the mobile terminal is resident within the geographic area.

**20 Claims, 3 Drawing Sheets**



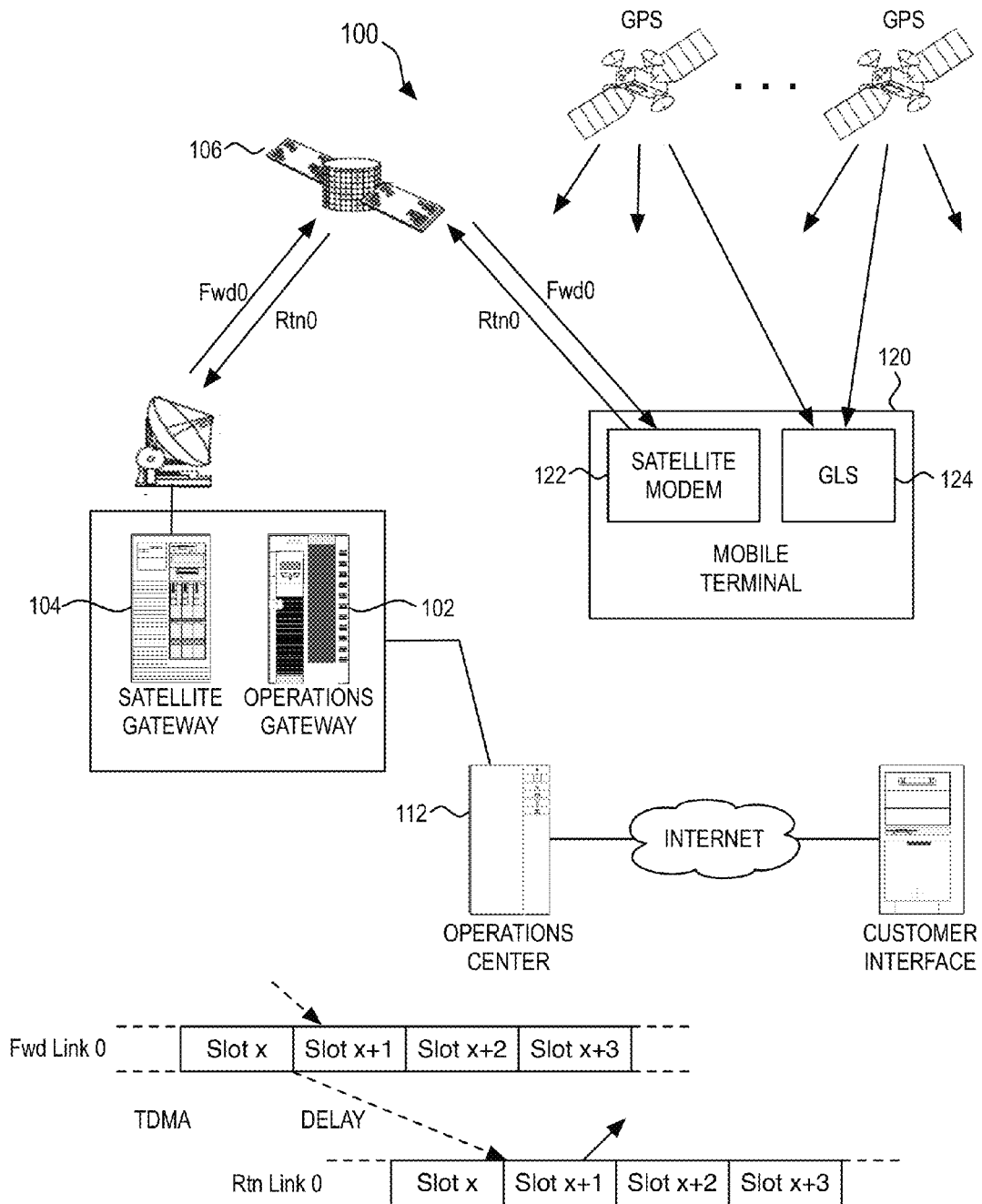


FIG. 1

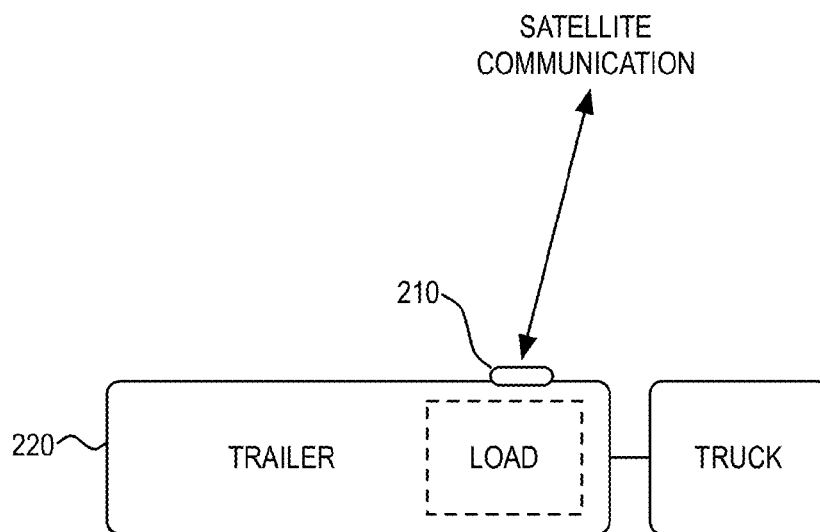


FIG. 2

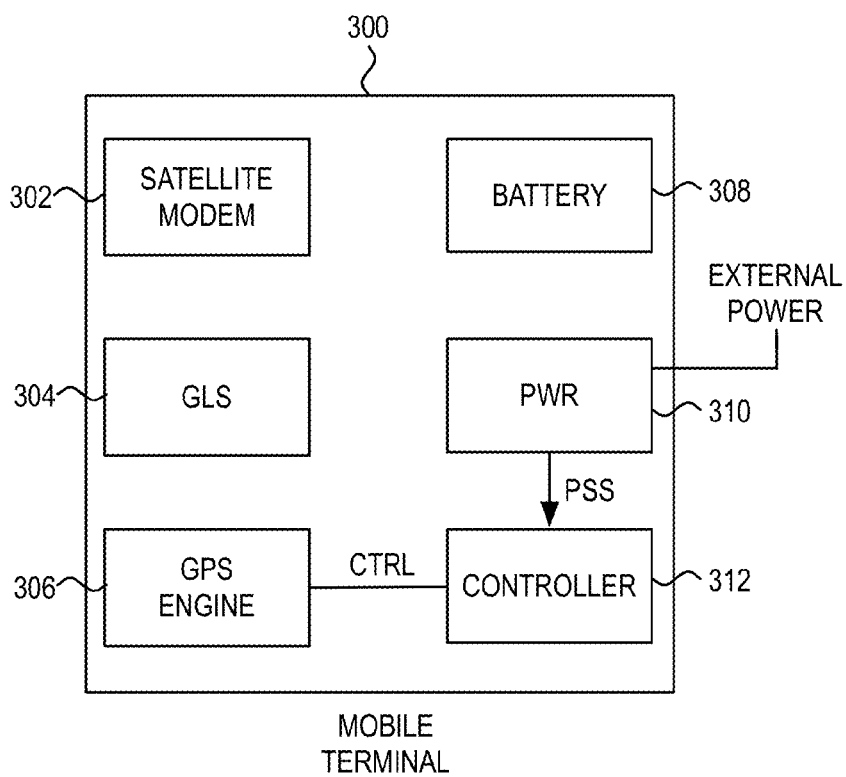
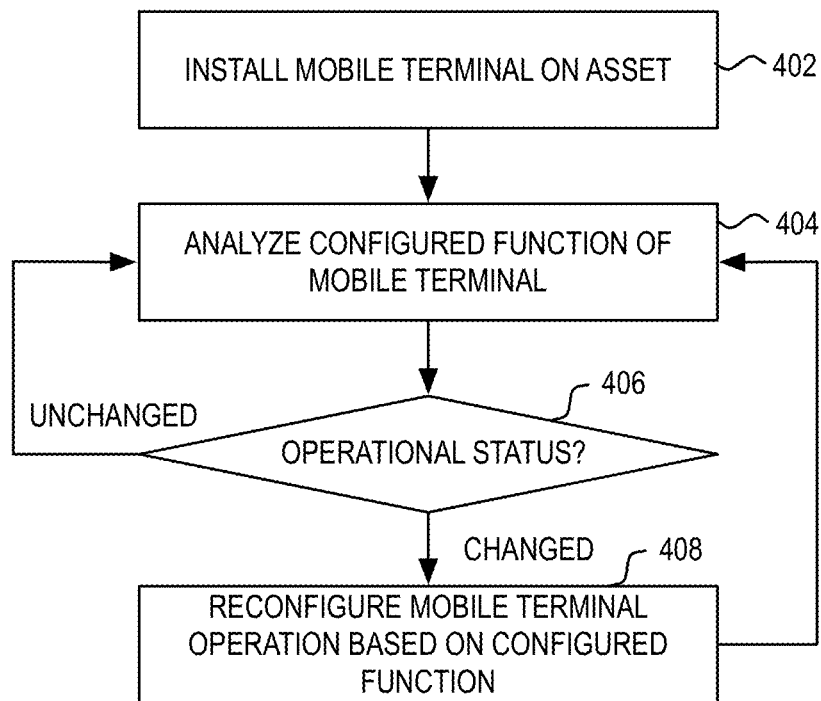


FIG. 3

*FIG. 4*

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## SYSTEM AND METHOD FOR ASSET TRACKING CONFIGURATION OF A MOBILE TERMINAL

This application is a divisional of non-provisional patent application Ser. No. 13/235,641, filed Sep. 19, 2011, which claims priority to provisional patent application No. 61/384,135, filed Sep. 17, 2010. Each of the above-identified applications is incorporated by reference herein, in its entirety, for all purposes.

### BACKGROUND

#### 1. Field of the Invention

The present invention relates generally to tracking and monitoring and, more particularly, to a system and method for asset tracking configuration of a mobile terminal.

#### 2. Introduction

Tracking mobile assets represents a growing enterprise as the need for increased visibility into the status of movable assets (e.g., trailers, containers, etc.) increases. Visibility into the status of movable assets can be gained through mobile terminals that are affixed to the assets. These mobile terminals can be designed to generate position information that can be used to update status reports.

In one conventional tracking system, the mobile terminal is affixed to the roof of the trailer. This location of attachment ensures that the satellite receiver in the mobile terminal maintains good visibility throughout the transport route. One of the challenges of such a mobile terminal installation is the powering of the mobile terminal. In one scenario, the mobile terminal can be powered by a battery. The service life of such a battery is dictated by the amount of power required by the mobile terminal in executing various tracking functions. The battery service life also dictates the associated maintenance costs, which would be required to service mobile terminals having depleted batteries.

What is needed therefore is a mechanism that maximizes the functionality of mobile terminals, while minimizing the impact on various constraining factors.

### BRIEF DESCRIPTION OF THE DRAWINGS

In order to describe the manner in which the above-recited and other advantages and features of the invention can be obtained, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. Understanding that these drawings depict only typical embodiments of the invention and are not therefore to be considered limiting of its scope, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

FIG. 1 illustrates an embodiment of a satellite network in communication with a mobile terminal on an asset.

FIG. 2 illustrates a mobile terminal affixed to an asset.

FIG. 3 illustrates a mobile terminal coupled to external power.

FIG. 4 illustrates a flowchart of a process for enabling asset tracking configuration of a mobile terminal.

### DETAILED DESCRIPTION

Various embodiments of the invention are discussed in detail below. While specific implementations are discussed, it should be understood that this is done for illustration

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purposes only. A person skilled in the relevant art will recognize that other components and configurations may be used without parting from the spirit and scope of the invention.

FIG. 1 illustrates an embodiment of an asset tracking system that includes operations gateway **102**, communicating with mobile terminal **120**, which is affixed to an asset. As would be appreciated, the asset can be embodied in various forms such as a truck, trailer, railcar, shipping container, or any other item of interest.

Communication between operations gateway **102** and mobile terminal **120** is facilitated by satellite gateway **104** at the ground station and satellite modem **122** in mobile terminal **120**. Both satellite gateway **104** and satellite modem **122** facilitate communication over communication satellite **106**.

In one embodiment, the satellite communication is implemented in a time division multiple access (TDMA) structure, which consists of 57600 time slots each day, per frequency or link, where each slot is 1.5 seconds long. On the forward link, operations gateway **102** sends a message or packet to mobile terminal **120** on one of the 1.5 second slots. Upon receipt of this message or packet, mobile terminal **120** would then perform a GPS collection (e.g., code phase measurements) using global locating system (GLS) module **124** and/or to perform sensor measurements and transmit the data back to operations gateway **102** on the return link, on the same slot, delayed by a fixed time defined by the network. In one embodiment, the fixed delay defines a length of time that enables mobile terminal **120** to decode the forward packet, perform the data collection and processing, and build and transmit the return packet.

In one embodiment, mobile terminal **120** can be configured to produce periodic status reports. In this configuration, mobile terminal **120** would wake up periodically, search for its assigned forward slot, perform GPS and sensor data collection and processing, and transmit the status report on the assigned return slot. In another embodiment, mobile terminal **120** can be configured to produce a status report upon an occurrence of an event (e.g., door opening, motion detected, sensor reading, etc.). In this configuration, mobile terminal **120** would wake up upon occurrence of an event, search for an available forward slot, perform GPS and sensor data collection and processing, and transmit the status report on the return slot corresponding to the identified available forward slot.

Upon receipt of a status report from mobile terminal **120**, operations gateway **102** passes the information to operations center **112**. Operations center **112** can then use the received GPS collection to calculate a position solution. This position solution along with any other status information (both current and historical) can be passed to a customer via the Internet. A detailed description of this communications process is provided in U.S. Pat. No. 6,725,158, entitled "System and Method for Fast Acquisition Position Reporting Using Communication Satellite Range Measurement," which is incorporated herein by reference in its entirety.

In another embodiment, mobile terminal **120** can be configured to transmit status reports to a low earth orbit (LEO) satellite. An example of such a communication process is described in co-pending non-provisional patent application Ser. No. 13/078,453, entitled "System and Method for Position Determination Using Low Earth Orbit Satellites," which is incorporated herein by reference in its entirety. As will become apparent from the following

description, the principles of the present invention are not dependent on the use of a particular type of communication satellite.

In one embodiment, mobile terminal **120** can also collect sensor measurements from sensors (not shown) that are positioned at various points on the asset being tracked. In meeting the demand for greater visibility into the status of assets, various sensor types can be used. For example, volume sensors, temperature sensors, chemical sensors, radiation sensors, weight sensors, light sensors, water sensors, RFID tags, etc. can be used to report the condition of cargo being transported or an environment of the asset. In other examples, truck cab ID indicators, odometer sensors, wheel sensors, vibration sensors, etc. can be used to report the condition of an asset transporter.

In general, the various sensors can be used to report status information or the occurrence of any events that can be associated with the asset to which the mobile terminal is affixed. The sensor information along with position information can be reported to the centralized facility periodically, upon request, or upon an occurrence of a detected event at the asset location. In various embodiments, the transmission of sensor information from the sensors to mobile terminal **120** can be facilitated by wired or wireless connections.

Mobile terminals are often affixed to an asset at a location that facilitates good visibility to the satellites. FIG. **2** illustrates one example of mobile terminal placement on an asset such as trailer, which contains a load. In this illustrated example, mobile terminal **210** is affixed to a roof of trailer **220**, which is pulled by a truck. At this roof position, the view of mobile terminal **210** to the various satellites is largely unobstructed. This unobstructed view enables mobile terminal **210** to maintain communications contact with the various satellites as it is routed to its destination.

To facilitate placement of a mobile terminal on various parts of an asset, the mobile terminal can be designed to operate using battery power. The effectiveness of this battery-powered solution is based on the battery lifetime. The greater the battery lifetime, the lower the maintenance costs in servicing the installed base of mobile terminals. One of the key factors in extending the battery life is minimizing the power demand of the mobile terminal.

As described above, the GLS module is designed to take GPS measurements and forward those GPS measurements to the operations center. In this GLS solution, the location of the asset is not determined at the mobile terminal. Rather, the location of the asset is determined at a remote operations center using the GPS measurements that have been forwarded by the mobile terminal. By this process, the power drain at the mobile terminal is minimized as the mobile terminal can be in an awakened state for a short period of time that is sufficient to collect and forward the GPS measurements to the operations center.

FIG. **3** illustrates an embodiment of a configurable mobile terminal according to the present invention. As illustrated mobile terminal **300** includes satellite modem **302** and GLS module **304** to perform the collection and forwarding of GPS measurements to the remote operations center.

In addition, mobile terminal **300** also includes GPS engine **306**. GPS engine **306** is generally designed to perform a GPS position determination locally at mobile asset **300**. One of the disadvantages of including GPS engine **306** in mobile terminal **300** is the substantial power requirements demanded by GPS engine **306**. More specifically, the power required to enable GPS engine **306** to determine its position multiple times per day would drastically reduce the life

expectancy of battery **308** in mobile terminal **300**. This drastically reduced life expectancy would produce a corresponding increase in the associated mobile terminal maintenance costs to unsustainable levels.

It is a feature of the present invention that the inclusion of GPS engine **306** in mobile terminal **300** can be supported through configurable functionality included within mobile terminal **300**. In the above example, the configurable functionality can be implemented through a configured function that is dependent on an input such as available power.

In one embodiment, the configurable functionality is based on an input such as the availability of external power. As illustrated in FIG. **3**, external power can be received at power module **310**. As would be appreciated, the external power can be provided by various methods depending on the type of asset to which the mobile terminal is affixed. For example, if the mobile terminal is affixed to a trailer, then the external power can be provided through a 7-way trailer connector when the truck is connected.

In the example embodiment of FIG. **3**, the receipt of external power at power module **310** of the mobile terminal can be used to generate a power supply status (PSS) signal that is provided to controller **312**. This PSS signal provides an indication to controller **312** that external power is available. The availability of external power to the mobile terminal, thereby indicates that the mobile terminal is not constrained by the power in battery **308**. This lack of constraint of the power available to the mobile terminal would then enable controller **312** to activate GPS engine **306**. In contrast, controller **312** would limit activation of GPS engine **306** if the power-based cost function indicated that the available pool of power would not justify the activation of GPS engine **306**.

As would be appreciated, FIG. **3** illustrates a simple embodiment where the power-based cost function can be based on the existence or non-existence of external power to the mobile terminal. More generally, the power-based cost function can be based on other advanced metrics that can consider power budgets based on internal battery **308**. For example, the power-based cost function can be based on the battery power level, the power consumed in a given time period, the priority of a function enabled by GPS engine **306** (e.g., user override), or any other metric that measures the relative value of power to be consumed by GPS engine **306**. Even further, the power-based cost function need not be based on a locally-generated signal. In one embodiment, the PSS can represent a remotely generated signal that is sent over a communication network. This remotely-generated signal can be based on remote monitoring of mobile terminal power, customer control, etc.

In general, the control of the activation of GPS engine **306** by controller **312** can be designed to maximize functionality of the mobile terminal relative to the availability of power to the mobile terminal. This control can be designed to meet the changing power environment in which the mobile terminal operates. For example, the mobile terminal can activate/deactivate GPS engine **306** to match the changing power environment in an intermodal transfer where an asset is being transported by different transportation segments based on truck, rail and ship transport. In another example, the mobile terminal can activate/deactivate GPS engine **306** to match a change in power environment due to failure conditions (e.g., fuse failure in a 7-way power scenario). In a further example, the mobile terminal can activate/deactivate GPS engine **306** to match the operating condition of the asset (e.g., construction equipment running versus idle).

In yet another example, the mobile terminal can enable or cancel a GPS position query based on a time needed for such a GPS position query. In general, GPS engine 306 would typically need 30 seconds to download ephemeris information periodically. If the current ephemeris information is already available to GPS engine 306, then a position query could take less than a second to arrive at a position fix. In this scenario, the power-based cost function can therefore activate/de-activate GPS engine 306 based on the expected power to be consumed by the GPS query.

GPS engine 306 can be designed to enable various on-board functions at mobile terminal. As would be appreciated, the principles of the present invention are not dependent on a particular GPS function implemented. In various examples, the functions enabled by GPS engine 306 can support on-board and remote implementations of virtual perimeter initiated tracking and actions, on-board and remote calculation of mileage for trips, directional indications, movement detection, etc.

To further illustrate the operation of a configurable function of a mobile terminal, reference is now made to the flowchart of FIG. 4. As illustrated, the process begins at step 402 where a mobile terminal is installed on an asset. Next, at step 404, the mobile terminal would analyze the configured function (e.g., power-based cost function) of the mobile terminal. As noted above, the specific form and input variables of the configured function would be implementation dependent. Based on the analysis of the configured function, the mobile terminal would then determine an operational status (e.g., GPS engine status) at step 406. If it is determined, at step 406, that the operational status of the mobile terminal should remain unchanged (e.g., GPS engine inactive), then analysis of the configured function would continue at step 404.

If, on the other hand, it is determined, at step 406, that the operational status should change, then the mobile terminal would be reconfigured in accordance with the configured function. For example, the GPS engine could be activated by the controller and the relevant GPS functions enabled by the active GPS engine would commence at step 408. The analysis of the configured function would then continue at step 404 to determine whether any further changes in operational status of the mobile terminal should be effected.

As has been described, a mobile terminal's operation can be configured based on an analysis of a configured function implemented by the mobile terminal. In the example above, operation of a GPS engine is based on an analysis of a configured power-based cost function implemented by the mobile terminal.

More generally, the analysis of a configured function implemented by the mobile terminal can be applied to other use scenarios. In one use scenario, the configured function can dictate the reporting interval (e.g., every X minutes, every Y hours, every Z days, etc.) of the mobile terminal. Here, variations in the reporting interval can be dictated based on an analysis of the configured function implemented by the mobile terminal. For example, the reporting interval can be changed based on a power-based cost function. Here, the control of the reporting interval can be designed to maximize asset visibility relative to the availability of power to the mobile terminal. In other words, the control of the reporting interval can be designed to meet the changing power environment in which the mobile terminal operates.

In another use scenario, the reporting interval, communication data rate, or message type priority can be changed based on a geographic cost function. For example, the reporting interval, communication data rate, or message type

priority could be altered based on a particular geographic area in which the mobile terminal is operating. An application of such a use scenario is a restricted geographic area application where transmissions in certain geographic areas are at risk due to potential security risks presented by the mobile terminal transmissions. In this scenario, the mobile terminal can be configured to alter the reporting interval, the communication rate, message type priority, etc. in response to the geographic restriction. While under these geographic restrictions, the mobile terminal can continue to accumulate sensor data, and would wait until the geographic cost function indicates that the regular reporting by the mobile terminal can commence.

In one embodiment, the identification of a geographic area in which a mobile terminal is operating is based on measurements of positioning satellites such as GPS satellites. As would be appreciated, an identification of a geographic area can be based on a variety of signals (e.g., a signal beacon) that may or may not provide an indication of an exact geographic location.

In yet another use scenario, a billing rate can be changed based on a geographic cost function. For example, the billing rate associated with the asset on which the mobile terminal is affixed can be adjusted based on a particular geographic area in which the mobile terminal is operating. An example application of such a use scenario is location-based billing where the billing rate associated with the asset can be adjusted when the asset crosses an international border or other geographic demarcation. Similarly, the billing rate can be changed based on a configured function that tracks a reporting interval, communication rate or type of communication from the mobile terminal. This enables certain communications intervals, rates, types, etc. to be billed at premium levels.

In one embodiment, the configured function implemented by the mobile terminal can be established via over-the-air configuration parameters. This enables the mobile terminals in the field to be configured remotely in implementing specific configured functions.

In the above description of an example embodiment, a communication satellite (e.g., GEO, MEO, LEO) can be used to transmit positioning information, sensor measurement, alert information, etc. to a remote operations center. The principles of the present invention are not confined to such a transmission mechanism. In other embodiments, the communication link between the mobile terminal and the remote operations center can be facilitated by a terrestrial cellular network, a short range radio network, or any other communication network that can provide a suitable communication path.

These and other aspects of the present invention will become apparent to those skilled in the art by a review of the preceding detailed description. Although a number of salient features of the present invention have been described above, the invention is capable of other embodiments and of being practiced and carried out in various ways that would be apparent to one of ordinary skill in the art after reading the disclosed invention, therefore the above description should not be considered to be exclusive of these other embodiments. Also, it is to be understood that the phraseology and terminology employed herein are for the purposes of description and should not be regarded as limiting.

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What is claimed is:

1. A mobile terminal, comprising:
  - a position tracking module that collects measurements from a plurality of positioning satellites, the collected measurements used to determine a position of said mobile terminal;
  - a transmitter that is configured to transmit status reports to an operations center; and
  - a controller that is configured to control an activation of the transmitter based on an analysis of a geographic cost function, the geographic cost function configured to identify a geographic area in which the controller alters a communication parameter of the mobile terminal, the alteration of the communication parameter used by the operations center as a basis for a change in a billing rate during at least part of a time that the mobile terminal is resident within the geographic area.
2. The mobile terminal of claim 1, wherein the communication parameter is a pre-emption of transmission to the operations center.
3. The mobile terminal of claim 1, wherein the communication parameter is a reporting interval.
4. The mobile terminal of claim 1, wherein the communication parameter is a communication data rate.
5. The mobile terminal of claim 1, wherein the communication parameter is a message type priority.
6. The mobile terminal of claim 1, wherein an input to the geographic cost function is a geographic location determined using measurements of the position tracking module.
7. The mobile terminal of claim 1, wherein the transmitter is configured to transmit position information to the operations center via a communication satellite.
8. The mobile terminal of claim 1, wherein the transmitter is configured to transmit position information to the operations center via a terrestrial cellular network.
9. The mobile terminal of claim 1, wherein the transmitter is configured to transmit position information to the operations center via a short range radio network.
10. The mobile terminal of claim 1, wherein the transmitter is configured to transmit sensor measurement information to the operations center.

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11. A method, comprising:
  - measuring, by a position tracking module in a mobile terminal, measurements of signals from a plurality of positioning satellites, the measurements used to determine a position of the mobile terminal;
  - transmitting, by a transmitter in the mobile terminal, status reports to an operations center; and
  - controlling, by a controller in the mobile terminal, an activation of the transmitter based on an analysis of a geographic cost function, the geographic cost function configured to identify a geographic area in which the controller alters a communication parameter of the mobile terminal, the alteration of the communication parameter used by the operations center as a basis for a change in a billing rate during at least part of a time that the mobile terminal is resident within the geographic area.
12. The method of claim 11, wherein the communication parameter is a pre-emption of transmission to the operations center.
13. The method of claim 11, wherein the communication parameter is a reporting interval.
14. The method of claim 11, wherein the communication parameter is a communication data rate.
15. The method of claim 11, wherein the communication parameter is a message type priority.
16. The method of claim 11, wherein an input to the geographic cost function is a geographic location determined using measurements of the position tracking module.
17. The method of claim 11, wherein the transmitting comprises transmitting position information to the operations center via a communication satellite.
18. The method of claim 11, wherein the transmitting comprises transmitting position information to the operations center via a terrestrial cellular network.
19. The method of claim 11, wherein the transmitting comprises transmitting position information to the operations center via a short range radio network.
20. The method of claim 11, wherein the transmitting comprises transmitting sensor measurement information to the operations center.

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